Developing a Virtual Reality for People With Dementia and Mild Cognitive Impairment Based on Their Psychological Needs: A Feasibility Study

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Abstract

Background

Purpose of this study was to develop a virtual reality (VR) intervention program based on the psychological needs of patients with dementia and mild cognitive impairment residing in nursing facilities in Korea to relieve their behavioral and psychological symptoms, and to confirm the possibility of utilizing VR in patients with dementia and mild cognitive impairment.

Methods

In the first phase, surveys and questionnaires were used to identify activities that relieved the behavioral and psychological symptoms of dementia (BPSD) among patients. These activities were classified into five types of psychological needs. In the second phase, a fully immersive, interactive, easy-to-use VR platform was developed that reflected these psychological needs. The VR content was used with patients with dementia and mild cognitive impairment. The researchers assessed the level of the participants' immersion, preference, and interaction with the VR, using a 5-point Likert scale.

Results

In the feasibility test, the mean immersion score was 4.93 ± 0.16 points, the mean preference score was 4.35 ± 0.41 points, and the mean interaction score was 3.84 ± 0.43 points. Six out of 10 participants required assistance while using the VR. The mean VR experience duration was 10.00 ± 3.46 minutes.

Conclusions

The VR-based intervention program that was developed to reduce BPSD was feasible for the participants, and provided them with a high degree of satisfaction and immersion. Furthermore, this study also confirmed the convenience and safety of the program. These findings provide evidence for the potential of VR to provide BPSD intervention programs for patients with dementia and mild cognitive impairment, and potentially for other geriatric conditions.

Background

The number of persons with dementia is rapidly increasing due to global population aging. According to Alzheimer's Disease International, there were c. 50 million individuals with dementia globally in 2018, which represents a 6% increase over 2015. The number of persons with dementia is expected to reach approximately 75 million by 2030 and 131.5 million by 2050 [1]. In Korea, the prevalence of dementia in persons 65 years and older as of 2018 was 10.1%, with the number continuing to increase subsequently [2].

Persons with dementia experience not only cognitive dysfunction, but also various behavioral and psychological symptoms, such as nervousness, depression, psychosis, yelling, and violence [3, 4]. Due to their lack of social and communication skills, as well as limitations in physical activity, persons with dementia experience issues in their relationships with others. This can lead to exacerbation of negative emotions, and behavioral and psychological issues in older persons with dementia [5, 6]. The behavioral and psychological symptoms of dementia (BPSD) are one of the most significant reasons why those with dementia receive early admission to nursing facilities [7]. This leads to higher social costs and lower quality of life for persons with dementia and their families [8].

Interventions that decrease behavioral and psychological symptoms among patients include drug and non-drug interventions; non-drug interventions focus primarily on reducing and removing the psychosocial or environmental risk factors associated with behavioral psychological symptoms [9], and on therapeutic approaches, such as recall therapy, horticultural therapy, music therapy, art therapy, animal-assisted therapy, and physical exercise [10-12]. However, it is difficult to apply existing cognitive-behavioral therapy to persons with dementia and decreased cognitive function; restrictions in the application of therapy also exist due to the lack of professionals who can provide this therapy [13].

Virtual reality (VR) refers to technologies that allow people to realistically experience situations or environments that are difficult to experience in reality [14, 15]. In particular, immersive VR allows for focus on sensory stimuli, and has been reported to facilitate positive emotions, as well as improvements in emotional state, interpersonal interactions, and communication [16-18]. Recently, VR-enabled interactions have been used to help diagnose dementia, as well as to facilitate improvements in cognitive function and rehabilitation [19-24]. Such approaches have been reported to be effective in improving emotional aspects, including the mood of persons with dementia [20, 25].

Cognitive training is often provided to persons with dementia, to address attention, memory, and reactions [26, 27]. However, this has remained an unattractive intervention due to the decreased cognitive function of such patients and the complex equipment needed to provide the training, which limits its applicability, while also resulting in high costs and bulkiness [28]. Furthermore, patients have complained of limited vision as they are cut off from the outside while wearing head-mounted displays; they have also complained about the heavy weight of these displays [15]. Some patients have exhibited symptoms indicative of maladjustment to VR, such as dizziness [29]. One study found that patients with dementia and mild cognitive

impairment experienced dizziness after their VR experience, and older patients experienced difficulties in operating the system due to decreased cognitive function [30].

There may also be differences in the motivation to participate in VR, depending on individual interests and tastes, aside from maladjustment to VR [13]. Most persons with dementia or mild cognitive impairment experience changes in their cognitive ability [4] and emotional reactions [6, 31]. However, the existing model for management patients with dementia is based on professional knowledge and not on individual characteristics [32]. Digital recall therapy that reflects individual preferences has been shown to induce interest in, and active participation by, participants [33]. Furthermore, given that programs reflecting individual traits and preferences have been effective as non-drug interventions [9, 34], it is important to consider the psychological needs and preferences of older persons with dementia and mild cognitive impairment when developing VR programs.

Studies have found reductions in anxiety and behavioral psychological symptoms in persons with dementia when their psychological needs are satisfied [35, 36]; such reductions have been effective in reducing the use of neuroleptics [34]. The psychological needs of persons with dementia include comfort (being free from distress and pain), identity (a sense of who they are), attachment (a feeling of security and safety), occupation (having a purpose in life), and inclusion (a feeling of belonging) [37]. There exist studies of patient-centered dementia care that considers these needs [38-41]; however, very few studies have developed activities or interventions preferred by persons with dementia by considering their psychological needs.

Therefore, the purpose of this study was to develop a VR-enabled intervention program based on the psychological needs of patients with dementia and mild cognitive impairments residing in nursing facilities in Korea, to relieve their behavioral and psychological symptoms, and to confirm the possibility of utilizing VR in patients with dementia and mild cognitive impairment.

The objective of the first phase of the study was to confirm the activities that relieve the behavioral and psychological symptoms of patients with dementia and mild cognitive impairment, and to classify these activities based on the patients' psychological needs. The objective of the second phase was to develop VR platform environments based on the patients' psychological needs to relieve the BPSD. The objective of the final phase was to evaluate the participants' VR immersion, their preferences and interactions with VR, and their tolerance for VR. \

Methods

Ethics approval and consent to participate

The project was approved by the Institutional Review Board of A University (MC18QNSI0055). Before participation, researchers obtained written informed consent from each patient and from the patient's legal guardian or representative. Participants were recruited by posting recruitment notices in facilities after obtaining approval from the managers of institution. Once identified, the manager who are the mental health expert spoke with patients to identify if the participants would agree to be contacted for possible study participation. Once agreed, we contacted the legal guardian or representative to recruit participants and obtain consent to participation. Informed consent was obtained from participants and their guardians. The participants were assured of the anonymity and confidentiality of all data collected. Informed consent was obtained from the participants and their guardians.

Again, there was an opportunity to ask questions and participants were informed of their right to withdraw at any stage from the study without giving a reason to overcome the short-term memory problems and variable capacity.

Phase 1: Psychological needs to relieve symptoms

This phase aimed to identify the psychological needs to relieve the symptoms of the patients by polling surveys and questionnaires. The source of the data was a large-scale research project focused on BPSD to develop an intervention program for improving quality of life. Details of the sampling process have been reported in Park et al. [42].

The following inclusion criteria were applied to select participants: having a confirmed diagnosis of dementia, aged over 60 years, experiencing behavioral and psychological symptoms, and reporting that activities provide relief. Data were collected from 325 participants, out of which 103 datasets were used in the analysis.

An open-ended question was asked of primary caregivers who had cared for at least 4 weeks for the patients with dementia participating in the study. The question addressed the activities that relieved BPSD in patients: "What activities relieve the BPSD of the patient for whom you are caring? [Additional file]" Answers were sorted and compiled into response categories and subcategories. In addition, qualitative data from the caregivers' narratives were analyzed thematically based on the psychological needs of patients with dementia [43-45].

Based on the five psychological needs of dementia patients [43], activities were classified into the character-strengthening aspects of comfort (being free from distress and pain, experiencing reduced anxiety by receiving tenderness and friendliness, and feeling soothed), identity (having a sense of self, knowing details of life history, knowing who one is in relation to significant others, and having a sense of continuity with the past), attachment (feeling security and safety, and trust), occupation (having a purpose in life, being empowered to have an impact), and inclusion (a feeling of belonging, being encouraged to interact with the social environment physically and emotionally). Two independent reviewers (A and B) classified the

relieving activities based on the psychological needs of patients with dementia. Any disagreements regarding activities were resolved through the judgment of a third reviewer.

Activities that relieve BPSD

Activities that relieved BPSD among patients were characterized and classified into five types of psychological needs. The need for “comfort” was rated highest in terms of providing relief from BPSD, with 36.9% out of a total of 103 patients making this assessment, followed by the need for “identity” (28.2 %), “inclusion” (24.3 %), “attachment” (10.7 %), and “occupation” (6.8 %). Activities related to the need for comfort included walking, eating snacks, physical contact such as hugging and holding hands, and creating a quiet environment. Activities related to the need for identity included religious activities, and visits from guardians and family. Activities related to the need for inclusion were conversation, and receiving positive support from others. Activities related to the need for attachment included checking objects (checking one’s clothes, placing a name sticker on personal closets). Activities related to the need for occupation included reading, solving puzzles, and playing Korean traditional card games (Hwatu; Table 1).

Phase 2: Development of VR intervention

The VR platform was developed considering the three elements elaborated below.

Reflecting psychological needs

The basis for the scenarios constructed was to fulfill the five psychological needs of comfort, identity, attachment, occupation, and inclusion of the patients with dementia, to strengthen the participants’ personality. The scenarios included to satisfy the comfort needs of the participants were physical touch (patting a friend on the shoulder), place of memory, forming a quiet environment, and walking. Identity need were met by visiting family and, viewing family pictures, while inclusion needs were reflected in the scenarios of conversation, being with someone, positive expression, and words/expressions of acknowledgment. The scenario of hanging out with friends and family was included to meet attachment needs, and occupation needs included scenarios such as selecting a destination that the patients wanted to visit, erasing graffiti, going grocery shopping, playing with dogs, and putting logs in the stove.

With the theme of “Train of memories,” this study implemented VR in 15 different places using four categories. The participant could choose the content via hand movements; the content was categorized into “Streets of memory,” “Nostalgic youth,” “Homely hometown,” and “Where I want to go.” In the “Train of memories,” the participant could choose their destination by handing a train ticket to the train station attendant and enjoy the scenery of the old train station. In the “Streets of memory,” the program depicted elementary schools of the past, neighborhood alleys, and old houses, and allowed the participants to experience games of slap-match in alleyways with friends, erasing graffiti on school blackboards, playing with puppies at home, and seeing family photos. “Nostalgic youth” was structured to include watching an old film at a theater, drinking tea in a traditional coffee house, and going home after shopping for groceries at a traditional market. “Homely hometown” allowed the participants to experience interactions such as playing in the waters of a valley, stroking reeds while walking in a breezy field, and placing kindling in a furnace in a rural home. In “Where I want to go,” the scenario did not include interactions, but included visual and auditory stimuli, with the major settings being those of orchards, Namiseom Island, the sea at night, observing crocks of condiments in the rain, and the Jungnogwon Bamboo Garden. There were no intellectual or functional demands in the user interaction with the virtual environment scenarios (Table 2).

Fully immersive and interactive VR

Virtual environment technology provides multimedia that may facilitate the storage and retrieval of memories. Accordingly, this intervention was structured to provide a fully immersive audio-visual experience of the different virtual environments. Sound, music, photos, and movies were added, in addition to anecdotes and verbal cues. To meet the psychological needs of the elderly with dementia, the scenario development consisted of environments, music, and sounds of nature suitable to foster the emotions of Korean persons.

The production method involved 360-degree video viewing, 360-degree camera recording, editing, and graphics production, which maximized the appearance reality and hence immersion. Interactions were implemented by attaching a leap motion to the Head Mounted Display, allowing for easy recognition of hand movements made by the participants.

The seasons and various animated objects could be manipulated through leap motion sensors (LM-010), allowing participants to interact with the scene through hand and arm movements. Particular movements triggered and moved animated objects such as train tickets, blackboard erasers, slap cards, puppies, teacups, radishes, valley water, reeds, and firewood. Participants did not need to use joysticks or keyboards.

Ease of use

Advanced, adaptable, and easy-to-use multisensory VR platform interfaces were considered that would permit implementation of strategies and procedures to facilitate patients’ interactions and navigation. The platform was built around the concept of untact, which allowed for easy solo use at home or with a little assistance, as well as overall ease of use, thereby ensuring the safety of the platform. Participants were seated next to their

caregiver or a research assistant (RA) throughout the VR session; postural demands were reduced by the participants remaining in their chair during the VR exercises.

Phase 3: Feasibility test

Procedures

Participants were recruited by posting recruitment notices in residential and daycare facilities for older persons. This study selected participants based on their being a resident or daycare visitor with dementia, aged 65 years or above, with a Mini Mental Status Examination-Korean version (MMSE-K) score of 15 or higher, a Clinical Dementia Rating of 0.5 or higher, and who understood the research process and agreed to participate. Exclusion criteria consisted of motor dysfunction due to cerebral infarction, other mental disorders, neurological disorders, and metabolic disorders. A total of 10 participants were recruited.

The VR-based intervention programs were provided to the participants in the program rooms of the institutions in 1–2 sessions of 20–30 minutes each. The intervention times were customized for the participants; lunch hours, visiting hours, and napping hours were avoided.

Participants' age, MMSE-K scores, and Activities of Daily Life (ADL) scores were obtained from medical records. The participants experienced VR-based intervention content after receiving guidance from trained researchers; two other researchers observed and posed questions to the participants, and recorded the real-time feedback from the patients through structured recording notes. The researchers asked the participants to respond to questions relating to immersion, preferences, and degree of interaction in their VR experiences on a 5-point Likert scale. Furthermore, the researchers recorded need for assistance, duration of VR experience, positive or negative experiences, and VR sickness to identify the participants' tolerance for VR [Additional file].

Based on the need-driven, dementia-compromised behavior model [46], complaining, agitation, wandering, hitting, grabbing, pushing, throwing objects, biting, hurting self or others, tearing objects or destroying property, and making physical/verbal sexual advances were recorded as negative behavior. Remaining seated and still, being focused, sleeping better than usual during nighttime, being calm, smiling, and communicating verbally or non-verbally were recorded as positive behavior.

Results

VR experience among people with dementia or mild cognitive impairment

The mean age of the participants with dementia was 85.80 ± 3.26 years (Min 82~Max 90), with a mean MMSE-K score of 21.44 ± 4.59 points, and a mean ADL score of 4.33 ± 2.88 points out of 30 points. As the participants engaged with the VR program, the researchers observed the level of the participants' immersion, preference, and interaction with the VR on a 5-point Likert scale. The mean immersion score was 4.93 ± 0.16 points, the mean preference score was 4.35 ± 0.41 points, and the mean interaction score was 3.84 ± 0.43 points. There were multiple indicators of tolerance of VR. First, 6 out of 10 participants required assistance while using VR. Second, the mean VR experience duration was 10.00 ± 3.46 minutes. Third, participant behavior throughout the VR was classified into positive or negative: Seven participants showed positive responses to VR, while the remaining three showed both positive and negative responses. Positive reactions by the participants included focusing on the program for a set period of time, laughing, and communicating verbally and non-verbally in a stable state; negative reactions included complaining of indifference and boredom, and expressing fear. Fourth, two patients reported VR sickness in the form of dizziness and headache (Table 3).

Discussion

This study confirmed the psychological needs of patients with dementia and mild cognitive impairment and developed a VR intervention program based on its findings, thereby contributing to improving the quality of life of the patients and providing effective care models for health professionals.

In this study, comfort needs were most frequently suggested as relieving behavioral and psychological symptoms in patients with dementia and mild cognitive impairment. Patients with dementia maintain their identity based on love and comfort, and thereby achieve personal growth [47, 48]. Furthermore, patients with dementia obtain happiness and enjoyment by engaging in meaningful activities, such as various leisure activities, social participation, and work-related activities [49, 50], which also contribute to improving the individual's sense of autonomy and identity [51, 52]. This study designed and developed a virtual scenario to meet the psychological needs of the participants by securing their emotional immersion and engagement in accordance with the preferences and emotions of Korean persons. Hence, findings of a previous study were considered, which highlighted that virtual scenarios should be developed that afford patients with dementia rich opportunities to participate in social interactions, and take ownership of conversations, utilizing multimedia data such as photos, audio, and video [53].

The VR content developed in this study was applied to patients with dementia and mild cognitive impairment, and evaluations were subsequently obtained of participants' immersion, preference, interaction, and tolerance for VR. A high degree of preference and immersion were confirmed among participants, thereby demonstrating the usability of the VR intervention program. It has been reported that patients with dementia more actively participate in activities that reflect their individual preferences [33], and if they are able to recall and reminisce about activities similar to those they have performed in the past [54-57]. This indicates that it is important for VR platforms to present a familiar environment given the historical and

cultural backgrounds of patients with dementia . Furthermore, intervention programs that reflect familiarity as well as various emotional stimuli can increase immersion and contribute to active interaction by helping the participants reminisce and recall the past [58]. Manera et al. [20, 59] reported that older individuals with mild cognitive disorders or Alzheimer's disease had higher levels of satisfaction, and reported less anxiety, discomfort, and fatigue when taking part in image-based VR exercises compared to paper and pencil exercises. The results of these studies indicate that well-developed VR content can be effectively applied to patients with dementia and mild cognitive impairment and can result in positive outcomes [60].

The current study found that the level of VR interaction and VR sickness differed across patients. The content of the VR platform was developed to allow participants to interact with the VR environment using various emotional stimuli generated in response to the leap motion sensor. These interactions required active movement and the use of vision and audition. However, older persons with dementia typically experience reduced visual and auditory capacity, resulting in decreased accuracy and attention [6], and the study results indicates that the participants experienced difficulties due to diminished sensory capacity..

VR sickness is a side effect of the process of VR immersion that manifests as symptoms such as dizziness or nausea [61]. VR sickness was experienced by 20% of the patients who participated in this study. The proportion was 70% in a study in which male and female participants had an average age of 26.5 years [62], and 43% in a study of middle- and high-school students [63]. While these symptoms are temporary, they differ according to multiple variables, such as underlying conditions and age [64]. Although an expanded field of view can increase VR sickness [65], clear images and accurate motion tracking can reduce VR sickness [66, 67]. Furthermore, head movements in a fixed position are consistent with how users experience reality [68], and content requiring less movement is less likely to lead to VR sickness [69]. The program developed in this study ensured adherence to the protocol without error given its ease of use; it was designed to reduce VR sickness by presenting clear images and capturing participants' hand movements via leap motion. Furthermore, it appears that the participants of this study reported relatively little VR sickness due to their experiencing the VR intervention program while seated, which decreased the effort required to maintain posture. The level of the participants' immersion, their preference for the system, and the immersion duration were all higher than the response scale midpoint, indicating that the participants were very likely to utilize VR-based intervention programs.

While VR-based programs have issues such as high costs, difficulty in operating the system, space constraints, and low portability [70, 71], the VR program employed in this study increased the convenience and safety of use by using simple interactive motions, such as pointing one's hand in the desired direction, avoiding the need for large, complex hardware.

VR platforms are expected to increase in usability for supporting individuals who require nursing, and therefore such systems are likely to experience increased demand. However, VR platforms have been typically underutilized in healthcare services for such groups as individuals with chronic diseases, other geriatric diseases, and those with disabilities [72], in addition to patients with dementia and mild cognitive impairment, for whom the usefulness of a VR program was been verified in the current study. The influence of VR immersion through the five senses of the human body is significant [73]. However, as VR studies to date have predominately adopted a technical approach [74, 75], it is necessary to research content development so that content complexity can be adjusted based on the cognitive function individuals with geriatric diseases whom such systems serve.

Conclusions

This study developed a VR-based intervention program for patients with dementia and mild cognitive impairment living in Korean nursing facilities based on psychological needs related to the alleviation of their behavioral and psychological symptoms. The VR-based intervention program developed in this study to reduce BPSD was feasible for the participants and provided them with a high degree of satisfaction and immersion. Furthermore, this study also confirmed the convenience and safety of the program. These findings build evidence for the potential of VR to provide BPSD intervention programs for patients with dementia and mild cognitive impairment and suggest the potential utility of VR programs for alleviating geriatric diseases.

This study was a feasibility test with a limited sample. As such, future studies should recruit a large sample of participants and consider factors such as age, gender, personality type, and severity of dementia. Furthermore, experimental research with a large sample size should be conducted to verify the long-term effects of the VR program developed in this study on BPSD.

Abbreviations

BPSD: behavioral and psychological symptoms of dementia

VR: virtual reality

MMSE-K: Mini Mental Status Examination-Korean version

ADL: Activities of Daily Life

Declarations

Ethics approval and consent to participate

The Institutional Review Board of C University (MC18QNSI0055) reviewed and approved the study protocol. Data were collected after participants provided written, informed consent. Participants were assured anonymity and confidentiality.

Consent for publication:

Not applicable

Availability of data and materials:

The dataset used and analyzed during the current study is available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions:

JH contributed to conception the study, conducted the statistical analysis and interpretation of the data, and drafted the manuscript. SM and HJ interpreted the data and drafted the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1. Classification of psychological needs based on relieving activities for BPSD (N=103)

Psychological needs	Relieving activities for BPSD	N (%)
Comfort	▪ Taking a walk, moving (from own room to living room), reading magazines (picture books) ▪ Taking medicine, receiving nutritional shots, getting one's prescription filled, sensory stimuli (listening to music, applying liquid painkiller), coffee, snack ▪ Creating a quiet environment, shutting the door, staying in one's room and coming out to the living room to exercise when no one is there, sitting in the toilet, taking a bath for more than an hour ▪ Doing what one wants when immediate request is granted ▪ Hugging, holding hands, physical contact, looking at the visitor log and confirming family's visit, listening to what others are saying, being told warmly that they need to leave tomorrow	38 (36.9)
Identity	▪ Reading the bible, hymnbook, listening to pastor's sermons, worshipping, thinking of God, always having prayer beads by the bedside ▪ Calling home, visit by caregiver, visit by younger sibling, visit by sons, visit by daughters, visit by grandchildren, photos with the family, visit by family, chatting with a daughter, receiving attention, told by son that he would call, told that their children are coming ▪ Isolated from daughter-in-law, refraining from visiting children	29 (28.2)
Attachment	▪ Checking for one's own belongings, checking for clothes, wearing familiar clothes, placing name tags in individual closets, touching individual belongings with permission from elderly with dementia, receiving what one wants, bags, radio (Far East Broadcasting) ▪ Going to the bathroom, toilet paper rolls, touching one's genital area (washing one's entire body thoroughly), asking for nighttime diaper care after touching one's genitals, putting on feces, less abnormal behavior when a woman takes interest and treats them, being cared for by the opposite sex	11 (10.7)
Occupation	▪ Walking exercise ▪ Hwatu (Korean traditional card game), puzzles, reading books, reading magazines (picture books), thinking of times when they spend money	7 (6.8)
Inclusion	▪ Conversation, talking, emotional support, taking their side to support, holding hands in conversation, warm conversation, face to face conversation, listening to what they want and appeasing them, staying with them, being a conversation partner while having their favorite snack, talking with them while meeting eyes, friendly and gentle approach, others answering well to the same questions, listening to complaints quietly ▪ Listening to positive expressions about own behavior, words or expressions of acknowledgment, emotional care (using cyclical language), attention from those that care for them and adaptation to the environment	25 (24.3)

BPSD = behavioral and psychological symptoms of dementia

Table 2. Summary of intervention program of virtual reality that addresses psychological needs

Scenario title	Places	Psychological needs	Contents	Multimedia	Interactive factors	Session length (min)
Train of memories	Train station	Occupation Inclusion	Admiring the scenery at the train station Boarding the train and choosing a destination	Sound of the train	Giving train tickets to station attendant	1
Street of memories	Elementary school Alleyway My homely house (City)	Identity Inclusion Occupation Attachment	Looking around the playgrounds and classrooms of elementary schools Playing with friends in the neighborhood alley Coming home and playing with puppies Receiving gifts and looking at family photos	Sound of puppies barking Family photo	Erasing graffiti on the classroom blackboard Playing slap-match Playing with puppies Receiving family gifts	4
Nostalgic youth	Theater Coffee house Market My homely house (City)	Identity Inclusion Attachment	Admiring the surroundings and entering the theater Watching an old film (Korea news) Drinking tea in a coffee house Visiting the market Coming home and playing with puppies Receiving gifts and looking at family photos	The bell rang at dawn (1972) New invention (1981) Olympic closing ceremony (1988) The sound of water boiling in kettle Market noise Sound of puppies barking Family photo	Video selection Drinking black herbal tea Buying radish Playing with puppies Receiving family gifts	6.5
Homely hometown	Valley Field of reed My homely house (Countryside)	Identity Comfort Attachment	Flowing water in the valley Walking in a field of reed Returning to the country home and lighting a fire in the furnace Coming back to the room and viewing family photos	The sound of flowing valleys Water splashing The sound of the wind passing through the reeds Crackling sound of fire Family photo	Dipping one's hand in the valley water Stroking the reeds Putting a kindling in the furnace Receiving family photos	3.5
Where I want to go	Orchards Namiseom Island The sea at night Crocks of condiments Juknokwon Bamboo Garden	Comfort	Walking through the orchards Taking a walk in the Namiseom Island Watching lighthouses, waves, and stars in the night sea Looking at the rain falling on crocks Walking through the bamboo forest while listening to Daegeum playing	Sound of cicadas Sound of the wind Sound of the waves Sound of the rain Sound of the wind, Korean traditional music		10

Table 3. Level of immersion, preference, interaction and tolerance of VR (N=10)

No	Assistance device	Immersion		Preference		Interaction		Tolerance for VR			
		M±SD	Min-max	M±SD	Min-max	M±SD	Min-max	Need assistance	Length of experience (min)	Participants reaction	VR sickness
1	Cane	5.00±0.00	5	5.00±0.00	5	4.63±0.35	4-5	No	15	Positive	-
2	Cane	4.85±0.38	4-5	4.85±0.38	4~5	4.38±0.45	4-5	No	15	Positive	-
3	-	5.00±0.00	5	4.92±0.29	4~5	4.64±0.75	3-5	No	10	Positive	-
4	Walker	4.65±0.24	4.5-5	3.55±0.37	3~4	2.80±0.76	2-3.5	Yes	10	Positive/ negative	+
5	Wheel chair	5.00±0.00	5	2.88±1.44	2~5	3.00±1.47	1.5-5	Yes	5	Positive/ negative	-
6	Walker	4.94±0.18	4.5-5	4.50±0.71	3.5~5	3.56±1.43	1-5	Yes	8	Positive	-
7	Wheel chair	5.00±0.00	5	5.00±0.00	5	3.63±0.48	3-4	Yes	10	Positive	+
8	Walker	5.00±0.00	5	3.70±0.67	2.5-4	3.70±0.67	3-4.5	Yes	5	Positive	-
9	Cane	5.00±0.00	5	4.28±0.51	3-4.5	4.00±1.41	2-5	No	10	Positive/ negative	-
10	Wheel chair	4.83±0.39	4-5	4.79±0.40	4-5	4.07±0.73	3-5	Yes	12	Positive	-
Mean±SD		4.93±0.16		4.35±0.41		3.84±0.43			10.00±3.46		

VR=virtual reality; K-MMSE=Korean mini-mental state examination; ADL=activities of daily living

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- questionnaire.docx